COLLEGE OF ENGINEERING

Chemical, Biological, and Environmental Engineering

REDUCING CONNECTIVITY OF NONWETTING PHASE IN POROUS MEDIA

Reduced connectivity of the nonwetting phase post-equilibration increases the nonwetting phase residual saturation. This project intends on determining which factors have the greatest influence on the interconnectedness of the nonwetting phase.

MOTIVATION

After the carbon concentration in the atmosphere surpassed over 400 ppm in 2013, The IPCC stated in their Fifth Annual Assessment Report that Carbon Capture and Storage (CCS) is necessary to keep the cost low when reaching climate goals. Increasing the amount of CO_2 trapped in the subsurface during geological sequestration would improve efficiency, thereby reducing the carbon in the atmosphere and decreasing the costs needed to do so.

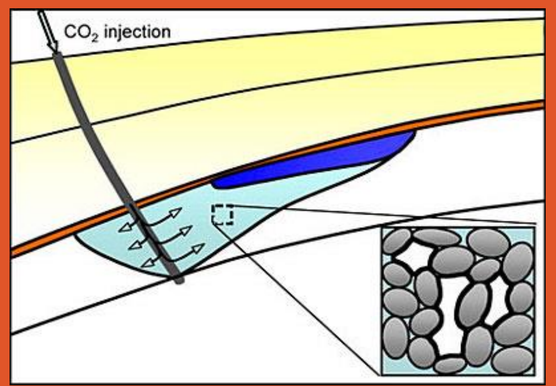


Figure 1: Capillary trapping of CO_2 in an aquifer

BACKGROUND

Geological sequestration can be used to trap CO2 through 4 different mechanisms. Structural trapping occurs when a large mass of the phase is held underneath an impermeable structure. Capillary trapping retains the CO2 in the pores. Over time, dissolution and mineralization takes place. As these trapping mechanisms occur, they increase in security. However, they also respectively increase greatly in time required.

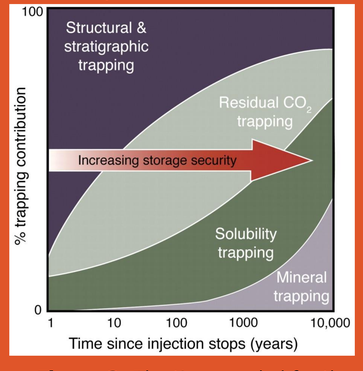
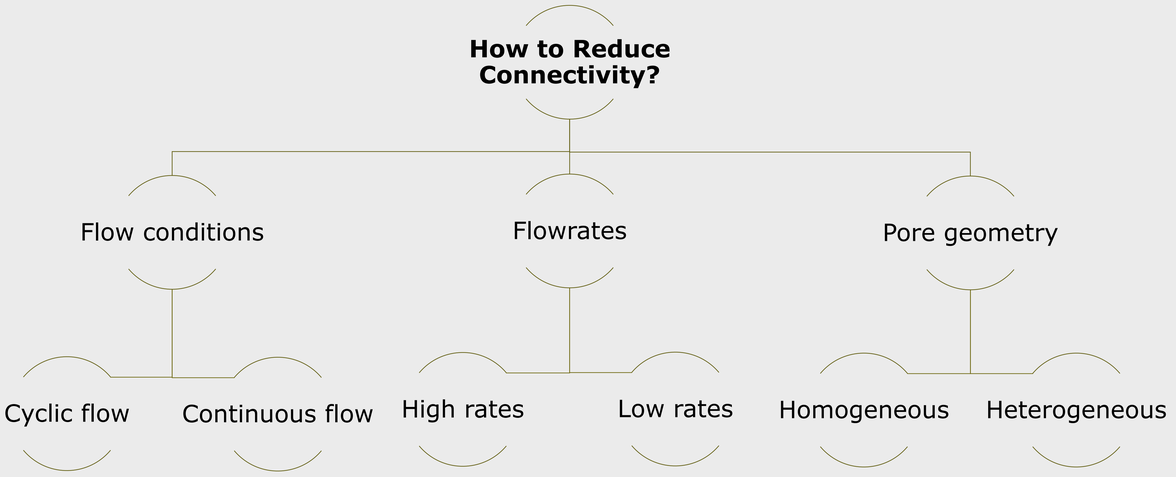


Figure 2: The time needed for the trapping mechanisms to take place

Oregon State University



PROJECT GOALS

1. Replicate results indicating cyclic flow's effect of reducing connectivity.
2. Determine the flowrate type that results in higher residual saturations of the NW phase.
3. Observe relationship between pore geometry and corresponding residual saturation.
4. Replicate findings with larger scales to ascertain these results are applicable in the field.

MICROTOMOGRAPHY TECHNIQUES

Prior to saturation, the dry sample will be scanned in the microCT scanner at Oregon State University. Following primary imbibition, primary drainage, and secondary imbibition, the sample is scanned after each stage to attain information on both the residual nonwetting and wetting phase saturations. This will indicate which parameters reduce connectivity and to what extent. The OSU microCT has a helical scanning trajectory, allowing the sample to rotate in front of the x-ray beams providing a full spectrum visual in one scan.

TEST MATRIX

These tests will be performed using a microCT scanner and analyzed using Avizo image processing software. Permutations of the following variables will be used for experimental testing:

Flow conditions: Cyclic and continuous flow

Flowrates: 0.1, 1 and 10 (mL/hr)

Media: Glass beads and sandstone

Sample Diameter: 0.65 and 2.5 cm

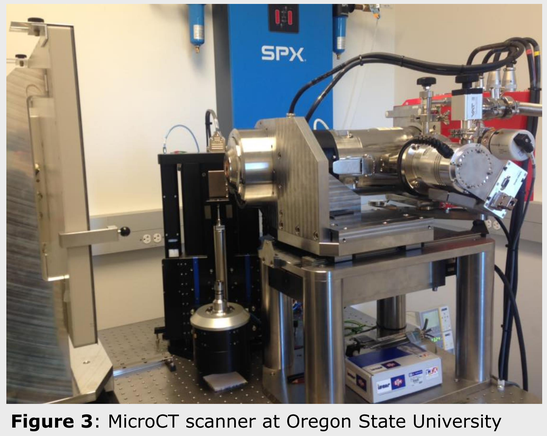


Figure 3: MicroCT scanner at Oregon State University

IMAGE PROCESSING

Avizo image processing software will be used to measure the surface area, interfacial area, contact angles, pore lengths, and residual saturations as well as connectivity and pore distribution. All four scans are aligned and further segmented into three phases (media, wetting phase, and NW phase) to extrapolate data on the fluids' connectivity and previously listed parameters.

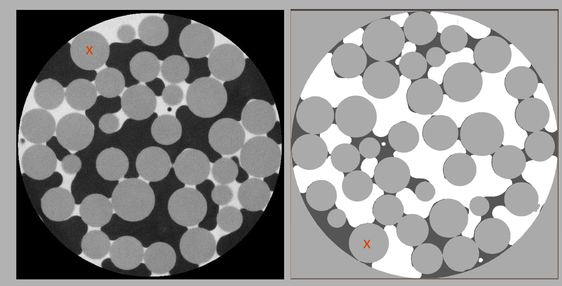


Figure 4: (a) Original greyscale image (b) Segmented greyscale image; The red "x" is placed on the same bead.

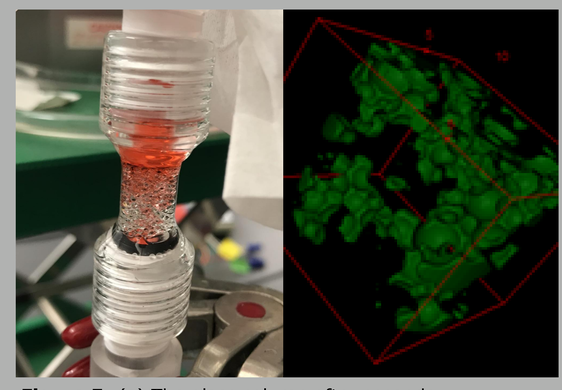


Figure 5: (a) The glass column after secondary imbibition. This demonstrates the residual saturation of CO2, using the red dyed Soltrol as a proxy fluid. (b) 3D presentation of residual nonwetting phase

EXPECTED RESULTS

1. Cyclic flow conditions will reduce the NW phase connectivity more than continuous flow conditions.
2. Lower flowrates will result in increased residual saturation of the NW phase.
3. Increased heterogeneity will result in decreased connectivity.
4. Increased scales will result in similar findings as the smaller initial scale.

RESEARCH TEAM

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